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ABSTRACT

Cooperation Metaphors are sets of rules to support interaction and collaboration between users who want to explore complex content and information together. The rules determine how the collaborative community can be created and managed, how members of the community can operate on their own, or cooperate with other members. Different types of situations, tasks and user roles determine different behaviors and therefore need different metaphors. The paper describes in general what cooperation metaphors are and how they can be defined. A number of examples, related to typical activities for virtual museums (museums on the Web) are used in order to give a practical understanding of what cooperation is, or can be. The paper also suggests that virtual metaphors lack some of the features of real-life cooperation, but, on the other hand, can also offer unexpected, powerful and effective possibilities not available in (traditional) real-life. Finally, the paper describes how collaborative activities for virtual museums can be implemented using today's tools and applications for collaboration on the Web, such as Net2gether, Microsoft Research's Virtual Worlds, and the WebTalk series. Includes three figures. (Contains 25 references.) (Author)

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PAPERS
Museums and the Web 2001

Co-Operation Metaphors For Virtual Museums

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Abstract

Cooperation Metaphors are sets of rules to support interaction and collaboration between users who want to explore complex content and information together. The rules determine how the collaborative community can be created and managed, how members of the community can operate on their own or can cooperate with other members. Different types of situations, tasks and user roles determine different behaviours and therefore need different metaphors. The paper will present the general issue, describing in general what cooperation metaphors are and how they can be defined. A number of examples, related to typical activities for virtual museums (i.e. museums on the Web) will be used in order to give a practical understanding of what cooperation is, or can be. The paper will also argue that virtual metaphors lack some of the features of real-life cooperation, but, on the other hand, can also offer unexpected, powerful and effective possibilities not available in (traditional) real-life. Finally, the paper will describe how collaborative activities for virtual museums can be implemented using today's tools and applications for collaboration on the Web; such as Net2gether, Microsoft Research's Virtual Worlds, and the WebTalk series.

Keywords; Collaboration, Virtual Museums, CSCW, CSCL, Virtual Reality

Introduction and Motivations

In most cases, users today access the shared space represented by a web site in isolation, with little awareness, or no awareness at all, of what other users are doing "at the same time". In a truly cooperative environment, by contrast, different users try to accomplish something together, accessing the shared space simultaneously and trying to collaborate to reach their goal. Several different goals may be the subject of cooperation: teaching/learning, shopping, design, supervising and monitoring, consulting, etc. Several different behaviours are associated with the notion of cooperation, but we should distinguish between two extremes:

- the cooperating users are peers, with similar knowledge and similar powers.
- one or more of the users control the situation, with knowledge or

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powers superior to those of the others, as for example tutors with pupils, shop-clerks and shoppers, tourist guides and tourists, etc.

One basic observation informing our work is that in the real world most activities are performed, if possible, in cooperation. Cooperating while trying to accomplish something very often appears more interesting, more engaging, more amusing or simply more efficient.

This initial observation is coupled with the fact that virtual shared environments have existed for a number of years. Initially they were text-based (IRC-II, MUDs, MOOs), allowing users to exchange typed messages, but they have evolved (Blaxxun Community, Virtual Worlds) introducing 3D graphics, audio, and other advanced features. In these "virtual worlds", as they are usually called, users are represented by virtual objects, called "avatars"; users can "move around", cooperatively interact with the virtual world and its objects, "talk" each other, etc.

These worlds allow a great deal of interaction among users, but they lack some of the features that we feel are crucial for an effective collaborative visit to a Virtual Museum:

User interaction seems to be the goal, rather than the means to accomplish something. Users amuse themselves by interacting, but they are not trying to get any specific result out of their experience. Visitors to a Virtual Museum, on the other hand, share the goal of better understanding the content and the background of the museum.

The amount of information being exchanged among users, or being made available by the world, is relatively small and loosely organized. Sophisticated museum sites by contrast convey a large body of sometimes very difficult knowledge.

The cooperation is loose, in the sense that users are free to behave as they want, with few constraints or enforced patterns. Our experience, however, shows that cooperation must be organized and follow precise guidelines in order to be effective.

Based on this we have been working on the following ideas since 1998:

- Access to a complex museum Website can be made more interesting, engaging and efficient by allowing a certain degree of cooperation among the users accessing the site at the same time.
- The cooperation must follow well organized guidelines, in order to be effective at reaching a specific goal (it could be learning, or shopping, etc.).
- A 3D virtual world, with avatars representing users "being there", can be an interesting space for an efficient and engaging cooperation.
- The information directly represented in the cooperation space (the 3D world) can't reproduce all the information of the Web site - the object of cooperation. Too much information, in fact, will clutter the cooperation space, making it less useful and effective.
- The cooperation space must offer enough information to allow the user to locate and find the objects on the Web site; once the parts of interest are located, there must be gateways allowing the user to "pass" to the selected portion of the Web site.

With the above prerequisites, a development environment, WebTalk-I (WebTalk, Barbieri, 1999) was developed and a few applications were developed. The best known of these applications was developed for the Museum of Science and Technology of Milan. The application, named "Virtual Leonardo" (Paolini, 1999), allowed users to co-operate while accessing a site with a number of pages describing different machines invented (designed but never built) by Leonardo da Vinci. Virtual Leonardo was presented in previous editions of Museums and the Web.

Virtual Leonardo allows users to visit the museum together, exchange opinions, and interact with the world and with each other in a number of ways: interactive gateways allow the users to visit the pages of the Website though standard Web technology.

Our experience with Virtual Leonardo, reinforced after collecting usage data and impressions from the users (Barbieri 2000), convinced us of the necessity to support the creation of such collaborative environments with a theory of design patterns. These are the subject of this paper.

Designing for Collaboration

Within a cooperative environment the goal, for a user, is to accomplish something specific (e.g. to get work done, to learn something, to buy something, etc.) through cooperating with other users. The other users can be at the same level of knowledge and power, or can be more expert and/or have greater control over the application. A number of visitors in a museum, for example, can be at a comparable level, while a museum guide is a user with more expertise and with the power to "take" the group of visitors around.

When the users interact with each other, they follow patterns of interaction that we call "cooperation metaphors". The goal of this section is to analyze the general features that cooperation metaphors must satisfy, in order to be effective, and at the same time engaging and compelling. The discussion that follows is based upon literature and our experience gained with WebTalk-I (Barbieri, 1999) and the deployment of applications.

First of all, in a cooperation environment, it is important that all actors share the notion of a common state, bound within time and space. The intensity with which this feeling is conveyed to all users determines the level of awareness (Gutwin, 1997) within the environment. The higher the awareness of the shared state, the better the cooperation between users: thus awareness is the primary effect we must create to allow users to work and discuss together. In a virtual space described in three dimensions, users can experience perceptual stimuli that are more similar to everyday life. By processing and understanding these stimuli, they can interact with the environment and the other actors, increasing their awareness, and creating in turn new stimuli for the others. In a collaborative system, this leads to the phenomenon of *prediction*; that is, participants can anticipate, within a short time, the actions of the others, because the number of informational details they have regarding the space and time they share with others (in one word, their awareness of the system) can lead them to such conclusions. (In this respect, for example, the "slow motion" of avatars in a 3D space can be more effective than fast motion or jumps, since the other users can better predict where an avatar is going if it is moving around slowly). Other important consequences of awareness are the possibility of learning

indirectly from other people's activity, or of gathering information from the state or behaviour of the artefact in the shared environments, or the possibility of using gesturing or indirect communication forms to support one's communication (e.g. "Follow me this way", "Take this..", etc.) when coordinating multiple actions for which more users are needed.

The problem in conveying the correct form of awareness is often application-related, meaning that not all kinds of collaborative information are always needed to perform a task within a determined environment. That is why before deploying a collaborative system it is important to design in advance the means by which information will be presented in three-dimensions (*Spatial Patterns*), and to determine precisely the rules by which users are able to cooperate with each other, and with the environment, and to enhance their awareness during their activity. We call this set of rules *cooperation metaphors*.

In our vision, a *cooperation metaphor* (Barbieri, 2000) is a set of *basic rules* that describe the different modalities of interaction between users and between users and their environment. These rules encompass various aspects, such as the way users can gather in groups to talk to each other or navigate virtual space, or how visualization of the state of the artefacts and of the avatars (the *figurines* which represent the current position of each user in space) is to be performed. By making decisions about all these aspects, it is possible to define a *global description* (a metaphor) of the possible forms of collaboration of users within a system. In the following section, we present an abridged list of these small rules, which can be freely selected to form any metaphor that is felt suitable to regulate collaboration within a certain application.

In addition, the design of the application also calls for deciding which *spatial patterns* are to be followed. Such decisions include whether the world will be represented in an abstract way or by mimicking reality in a simplified way (Bridges and Charitos, 1997, Benford and Snowdon, Hearst, and Karadi 97). Moreover, we must decide how to represent, in a consistent fashion, important visual elements that aid the navigation in space of the users, such as *places* (Cerulli, 1999), *thresholds* between one space and the other, *landmarks* to assist users in finding their own routes within the space (Charitos and Rutherford, 1997), *spatial hyperlinks* to jump from one point of the space to another (Campbell, 1996, Charitos, 96), and so forth. We will not investigate this complex issue in detail in the present paper.

Our (limited) experience in designing cooperative applications has shown that although the basic cooperation metaphors are the same, the way to actually implement them or to assemble them, changes from application to application. The role of the designer of a collaborative environment, therefore, is not solely limited to gathering contents and drawing 3D geometries, but includes conceiving a consistent pattern of cooperation metaphors suitable for the different application situations; the designers, in other words, must describe the rules for the collaboration between users.

A generic package for supporting cooperation over the Web, therefore, must not provide a fixed set of cooperation metaphors, but rather must present the designers with a vast range of possibilities that can be selected and tuned to the specific needs of the application. This functionality is lacking in all the Virtual Communities tools available today, and that is why we are designing WebTalk-II, a collaborative

environment where powerful cooperation metaphors can be combined and tuned at will.

Cooperation Metaphors for Virtual Museums

With some oversimplification, we may state that collaboration can be represented with two visualization paradigms corresponding to 2D and 3D representations. While both representations are in fact two-dimensional, since the visualization field is a 'flat' computer screen, the main difference between the two is that the first visualization paradigm causes the users to think in term of flat geometric elements and flat structures (windows, icons in windows, buttons laid in a bidimensional grid...), while the 3D paradigm utilizes perspectival projection to convey a sense of spatiality and immersion. Very often this paradigm takes advantage of a subjective view; that is, the users infer position in space by viewing a perspective representation of immediate surroundings, but without the ability to see themselves (exactly as in Real Reality). This is usually the approach taken in gaming and web-oriented virtual reality. In high-end virtual reality systems that make use of complicated devices such as gloves and head-mounted displays, there is an effort to convey much more immersion to the user, by tricking the human eye into seeing depth and space in a synthetic computer generated scene.

Most of the collaboration patterns can be implemented in either 2D or 3D. In 3D, however, it is possible to conceive a set of collaborative situations that are impossible to represent in 2D, and which can convey a very heightened mutual awareness. In the following we will list the most important collaborative elements, and we specify how they could be implemented in 2D or 3D. For some of these cooperation patterns, it is possible to describe situations that have no match in reality, but can be effectively used for the purposes of particular applications. We will point out some of these cases.

At the end of this survey, we will describe sample scenarios with which these collaborative sets can be composed into collaborative behavioural patterns to support a virtual museum application, by using commercial or research tools available today.

Distribution of the Shared State

A shared state is a collection of information about the status of each participant in the application. In 3D environments, it could be the avatar position and its movement or idle state, or the status of a shared resource, like the writing on a collaborative whiteboard. Each user can participate or be isolated from the shared state (and in this last case, it cannot be part of the collaboration mechanisms). The sharing of the state works on two levels:

- **Sharing Space:** All the modifications in space are shared (movements, changes in the bounding environment)
- **Sharing Time:** The unit with which time passes, and current time and speed of the animation, are common between the users. It is possible for users to cooperate in a common environment only if they share the same notion of space and time.
- **Integral Sharing:** All users within the system or the application share the same events. All of them thus have the same notion of the environment at a given moment.

- **Group Sharing:** The shared state can be partitioned in sub-groups; that is, several parallel different states can exist for the same environment. Each participant can belong only to one of the state partitions at a time.

Mutual Exclusions

If space and time sharing are not enabled simultaneously, it is not possible to support collaboration. If space and time sharing are enabled, an Integral or Group sharing mode has to be specified. If Integral sharing is used, it is not possible to enable Group sharing and viceversa.

Enhancement of these collaborative patterns over reality

The possibility of creating applications in which time is counted differently between users, or in which for a same environment there exist several possible states at the same time, has no counterpart in real reality. The first option can be used to let users experiment with artefacts or situations with different speed and timings. The second option is interesting to create multi-path situations in which different choices give rise to different events. An application could model this line of thinking and supply the users with an original way to experiment with this, using Group Sharing.

Grouping Mechanism

Grouping mechanisms refer to rules set to the management of user groups. Groups are a means tocluster users by interest or activity; each group shares particular cooperation elements, and behaves following a common pattern. Each group has to be identified by a unique name, so for example a group created to discuss Modern Painting following a renowned critic may be entitled "ModernArtCritique", while a group designed for free browsing around the museum resources can be called "StrollingAroundTheMuseum". Group management is handled by the following four subcategories.

- Group Creation: rules how groups can be formed within the system
  - **Dynamic:** it is permissible to create a new group, with no restrictions. The user that requests the creation of the new group is called the *owner* or *creator* of the group.
  - **Fixed:** the designer of the collaborative environment prepares in advance different groups with different names (as at pre-arranged thematic conferences, for example). The *owner* is the designer himself or any user that can be determined by a pre-arranged password (see *Leadership Management*).
- Group Protection: defines how a group can be entered by a user
  - **Free:** any user can join the group at leisure.
  - **Password:** the user can join only if he knows the related password.
  - **Fixed Quota:** the user can join only if the current number of users in the group does not exceed the maximum number requested by the designer of the application
  - **Banning:** it is possible to attach to the group a list of particular users who cannot join the group under any conditions (they are banned).

Kicking: other users are allowed to force a user out of the current group. Usually this operation is tied to some kind of privileged status.

- Group Disbanding: defines a criterion by which a group has to be disbanded.
    - **Persistent:** the group remains active and joinable even if no users are participating to this group.
    - **Dynamic:** the group and all its rules are destroyed when the last user leaves.
    - **Forced:** a particular user can force the disbanding of the group, scattering all its current participants. This can happen only if there is the availability of a free group to host all dispersed participants (usually called *global*).
- Leadership Management: in many collaborative situations the users do not cooperate on the same level, but one or more participants may have special abilities (they lead the way, or they show an object, or are the only participants enabled to talk). *Leadership* models a particular privilege within the collaboration, and the mechanism by which leadership is acquired and passed on has to be specified.
    - **Forbidden:** once leadership is acquired, it cannot be passed on.
    - **Password Protected:** leadership can be acquired by providing the proper password.
    - **Op-Passing:** a user who holds leadership can yield it to another user in the group.
    - **Inheritance**: users with leadership can grant leadership to one or more other users, without yielding their own leadership.
    - **Tokenized:** leadership is a token that can be acquired by the first user who requests it. There are as many leaders as leadership tokens available. For someone to acquire leadership, a token must be available. Users with leadership can yield leadership, thereby freeing a token.
    - **Creation Based:** in free group formation mode, leadership is automatically granted to the user who creates a new free group.

Mutual Exclusions

A group can be either dynamic or fixed. Similarly, it can be either free or password protected, but both types can have a fixed quota, banning and kicking. Only one type of disbanding can be specified. Leadership management can be defined by using more elements at a time; that is, leadership can be Creation Based and Forbidden, or Creation Based and Tokenized. Some of the management elements cannot be used together, e.g. leadership cannot be Tokenized and Inherited.

Enhancement of these collaborative patterns over reality

Group collaboration in real reality is usually described by a Creation Based, Forbidden leadership pattern, with a fixed/fixed quota group creation and dynamic disbanding. There is no complex notion of leadership management in real groups. In virtual collaboration, leadership can be spread over the group and be used to control enhanced collaboration facilities. (See for example visualization and view-point shifting capabilities).

Information Flow

Information flow rules can be attached to any other cooperation element to specify which are the directions and modalities in which information can be transmitted during collaboration.

- Pull: information transmits from the information provider to the information consumer because the consumer explicitly asks the provider for a piece of information (*pulls* information from the provider).
- Push: information transmits from provider to consumer, because the provider explicitly publishes new information for the consumer.

Mutual Exclusions

Push and Pull modalities can be used simultaneously. For example, a textual message or information item can be pulled or pushed, even if usually the message text is pushed to the user when new messages are incoming (as phone calls are pushed to your cell phone). Push and pull are particularly effective in visualization, where it can be decided if one user wants to see from the point of view (through the eyes) of another user, or conversely if one user wants to force other users to see what he sees (pushing his view onto others). Moreover, it could be possible to push one's position to others, to force other users to determined positions in the virtual space, and so on.

Enhancement of these collaborative patterns over reality

Push and pull are in general common modalities for textual and vocal communication, but are uniquely an achievement of virtuality when it comes to visualization and physical position.

Visualization

- Personal View: the kind of visualization each user has of the environment in which he is immersed.
  - **Normal:** purely subjective, from his own eyes
  - **Proximity:** from a camera external to the avatar, but placed near to it
  - **External:** from an external camera that chases the avatar, but at a distance
  - **Bird's View:** from a fixed camera placed in an elevated place
  - **External Avatar:** from the eyes of another avatar (a *tour guide* or a *friend*)
- Scene View: modifies how other avatars are represented in the environment
  - **Global:** all avatars belonging to all groups are visualized
  - **Group:** only avatars of the same group of the user are visualized
  - **Selective:** only some particular, selectable avatars are visualized

Mutual Exclusions

Personal views can all be used, or forbidden for particular application-related reasons. However, only one kind of view at a time is possible. Scene views are all mutual exclusive.

Enhancement of these collaborative patterns

Visualization elements strongly enhance the daily experience of collaboration in reality. In virtual realities it is possible to see oneself acting, or to incarnate other users by seeing from their eyes. This yields enormous gaming, demonstration and collaboration potential.

Movement

Specifies which kind of movements are allowed to users in the environment. Movements can be restricted for educational or navigational purposes within the particular application.

- Normal walking: allows users to wander freely in the environment by contiguous movement (walking)
- Near Jump: allows jumping in space next to another avatar of choice
- Zone Jump: allows jumping in space inside a predefined landing zone (also known as 'teleporting')

Mutual Exclusions: All movement modalities can be allowed simultaneously.

Enhancement of these collaborative patterns

The usual pattern in reality is normal walking in contiguous ranges of time and space. In virtuality the possibility of hyperjumping, not present in reality, enables a more effective collaboration.

Self-Representation

Self representation describes the means by which the particular state of the user can be represented. These elements can be enabled or disabled according to their relevance to a particular application.

- Emoticons: *emoticons* are short sentences or adjectives, often coupled with symbols, drawings or animations, that represent the emotional state and feelings of the user. They are used to better convey a meaning, and thus enhance cooperation. Example are: *smiles, *shrugs, *whistles, *frowns, *yawns, *blows a kiss, *strikes a pose, etc. etc.
- Degree of Presence: *degree of presence indicators* indicate the involvement of a user within an environment. The representation can be textual or symbolic. Some examples are: busy, do not disturb, away, extended away, free for chat, etc. (The ICQ)

Text-based Communication

In most virtual environments, the most effective mean of communication is still text based: users type in what they want to say to other users, and read the answers. Some environments also offer vocal communication,

and there is a pattern about governing vocal communication that we will not discuss here. Still, it is hard to operate in a 3D synthetic environment and talk. For a number of reasons, typing is still the favored method at the moment.

- Free: everybody can talk to all users in all groups, and receive messages from them
- Group: talking and listening is limited to within the group
- Group Restricted: like Group, but only users with leadership can talk; everybody else just listens (reads).
- Whisper: one user talks directly to another user, without being heard by the rest of the group
- Private: one user establishes a permanent talking session with another user, like a group composed of only two people
- Multiple Whisper: like whisper, but with multiple recipients

Mutual Exclusions

Free mode, Group and Group Restricted are in mutual exclusion. The rest of the elements can be used in combination with these first three.

Enhancement of these collaborative patterns

These elements model how talking can happen in real collaboration sessions; however, multiple whisper and group restricted elements may be harder to enforce in reality than they are in virtuality.

Using tools and metaphors for creating collaborative museums

We will now present a short survey of some software tools that enable us to create collaborative virtual environments for museums, commenting on how they can be used to enforce collaboration metaphors in the ways we presented them. Some of these are strictly 3D Virtual Environments (Zyda and Singhal 99), which strive to present a perspectival representation of the environment in which all participants are immersed. Others simply provide users with a way to collaborate over the Internet with usual 2D metaphors. Still, they can be usefully employed for museum applications, and they do use some of the cooperation elements we mentioned earlier.

WebTalk-I

WebTalk-I (see papers in previous M&W conferences,(Barbieri 2000. T. Barbieri 99)) allows you to draw a 3D environment that represents a virtual exhibition, and publish it on the web. Users that connect to the web page are presented with the 3D representation and can navigate in it together with others, seeing the other users and chatting with them.

There are two co-peration metaphors, fixed and imposed by the framework:

- Free Visit to the Museum
    - Groups can be created and disbanded dynamically, and they allow free access. It is thus possible for users just to form their own groups, or join any group, and start visiting

the museum freely, like in reality. Text communication is grouped, and there is a whisper mechanism. Movement can be by walking, flying, and zone jumping to important spots of the museum. Visualization allowed is Normal.

- Guided Tour of the Museum
    - Leadership in groups is tokenized, so any participant can acquire it and become a *Tour Guide*. In this metaphor, other participants can follow the one who acquired leadership, and *pull* inside their point of view what the guide is looking at (in simple words, seeing from the eyes of the guide), using the External Avatar visualization mode. This enables us to make very interesting virtual guided tours inside the virtual museum.

Fig. 1. In WebTalk-I, collaboration is supported via a fixed set of collaboration metaphor-s, like free-formed groups, and a guided tour in which leadership uses a tokenized mechanism.

WebTalk-II

The goal of the WebTalk-II framework is to provide an environment in which it is possible to design and deploy 3D collaborative environments, acting as a way to improve the access to "traditional" Web sites. There is no assumption or constraint about the technology used to implement the Web sites, nor any implication about the design "philosophy". It is clear, however, that well structured and well behaving Web sites, like the ones that could be obtained using a proper design methodology (HDM and W2000, Rohel, 1997, Bochicchio and Paolini, 1998, Bochicchio and Paolini, 1999, Garzotto, 2001), are targets of specific interest. In addition, there is the further requirement that WebTalk-II must be able to interface to Websites where pages are not statically defined, but dynamically generated (it is in fact much easier to define gateways to a

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set of statically defined pages, than to a set of pages with number and content dynamically defined), according to user requests. The JWEB (Bochicchio et al 1999) environment is one, of the many available, that does exactly this.

Consider, for example, the need to coordinate access to a number of pages, for a museum application. The user accesses an "index page" that allows "navigation" to the item of interest. In a collaborative environment, the equivalent of the index page is a 3D sub-space, where the users move through visualizing "gateways" to the indexed pages.

In "Virtual Leonardo" for example, the index is represented by a virtual "cloister", while each page is represented by a virtual room. Each room, in turn, contains an exhibit that can be browsed in a collaborative fashion with other participants.

Unlike WebTalk-I where you can have only free groups and pulled visualization from a privileged group user (to form a "guided tour group" metaphor), WebTalk-II allows you to specify (for any virtual exhibition one may design and implement), any possible combination of the collaboration elements discussed earlier in the paper, choosing the best way for people to work with each other given the particular nature of the exhibition the virtual museum is proposing. In other words, you can conceive any cooperation metaphor you like, assign it a name, and specify its properties by enabling or disabling each of the collaboration elements designed above.

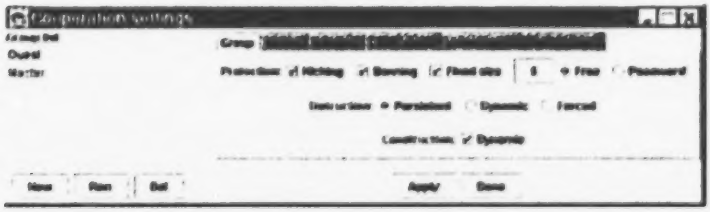

Fig. 2. The designer is able to define the general access structure, and specify which rules to enact for the collaborative exploration of the museum (creating cooperation metaphors).

Net2Gether

Net2Gether (http://www.net2gether.com) is an interesting tool for 2D based collaboration over the Web. It provides a chat window under the usual browser window. Chat is organized in groups, and each group has a leader. The leader is able to push the Web page being visited into the browsers of the other participants. It is thus possible to 'share' the 2D navigation of the museum Web site. The tool also allows pre-recording of sequences of chat messages and of navigation events within the site, and plays it remotely to the users. In this way it is possible to create various exploration paths within the exhibition proposed in the museum Web site.

Since Net2Gether has no notion of what cooperation metaphors are, it is not possible to change the way users collaborate. N2G metaphors are thus fixed. They can be classified as:

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- Guided Tour
    - Uses Dynamic group creation, with free protection, and the possibility of banning and kicking. Disbanding is dynamic as well. Leadership is creation based, and there is an opposing mechanism that allows other people to push web contents to the group. It is interesting to note that leadership cannot be inherited, as only one user must be able to push web contents to other users. Movement and Visualization elements are not used, since the environment is 2D. Text based communication is grouped and there are mechanisms for whispering and private communication.
- Pre-Recorded Guided Tour
    - In contrast with the Guided Tour metaphor, this metaphor requires fixed groups, with a fixed number of participants. The group is also persistent. Leadership management is forbidden, since it is the system that does the pushing of the content. Communication can be either Grouped or Group Restricted.

Microsoft Virtual Worlds

Microsoft Virtual Worlds (Microsoft Virtual Worlds) is an authoring environment for creating 3D Collaborative Virtual Environments (http://www.vworlds.org). Even if there is not an explicit way to model general Cooperation Metaphors in the sense we described in this paper, Virtual Worlds provides the designer with a high degree of flexibility, allowing them to define, for each object, sets of attributes and properties describing them. Some of the most common cooperation metaphors in virtual museums deployed with Virtual Worlds might be:

- Free Visit
    - Virtual Worlds does not directly support the notion of groups, but divides users in *rooms*, with the idea that only users in the same virtual room can talk to each other, like in any real environment. So even if communications can be considered Group based, the Groups are all predefined and persistent. Movement can be done by free walk, zone jumping and near jumping to another avatar. Visualization is extremely flexible, and can be of Normal, Proximity, External, Bird's View type, at the designer's will. It is possible to push and pull visualization to any External Avatar. VW also has a well designed system of *Emoticons* which allow users to express their feelings by modifying the posture and expressions of their own avatar representation.
- Piloted Guided Tour
    - Extends the Free Visit metaphor, with the possibility of attaching a camera to a particular automated Avatar which can play the role of a semi-intelligent and automated virtual guide in the museum. The users can pull in the visualization of this particular camera and enjoy the ride.
- Treasure Hunt
    - Virtual Worlds augments collaboration by using the notion of ownership of objects (abridged from the brief sketch of collaborative elements presented in this paper). It is possible for users to take objects from the worlds, giving rise to the possibility of organizing collaborative games or

activities like '*treasure hunts*', where the guide invites the participants to look for a particular object in the museum, mixing entertainment with education.

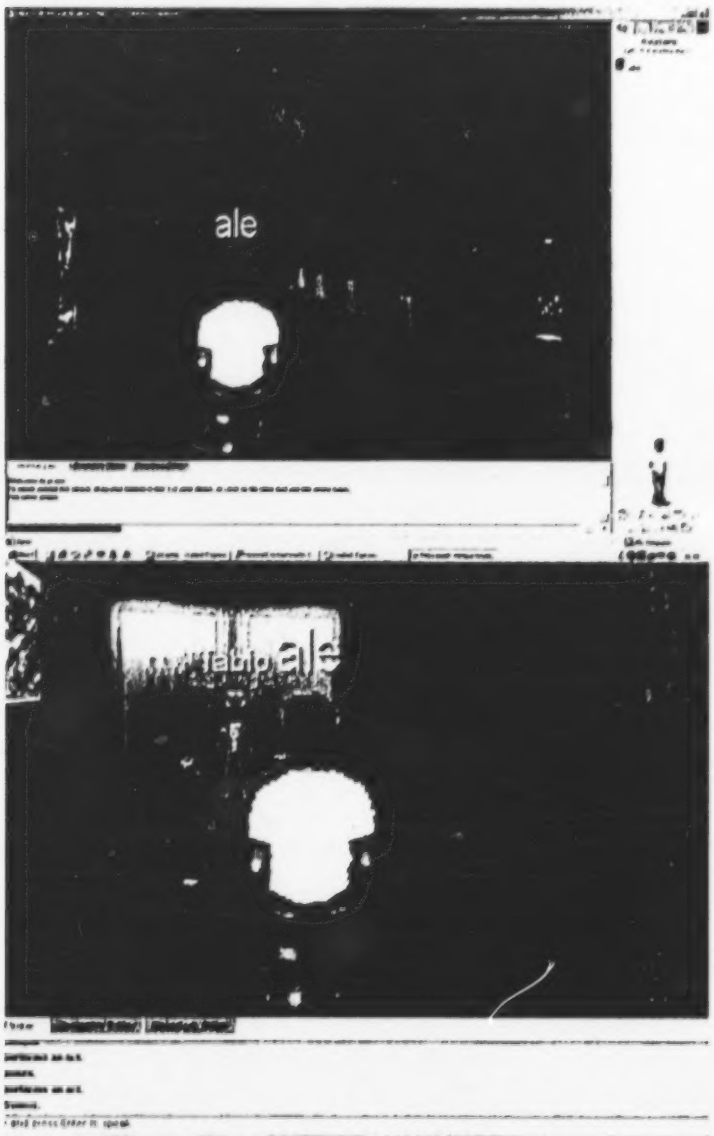

Fig. 3. An art gallery of a museum can be freely navigated with walking movements in Virtual Worlds (top). Virtual Worlds' Emoticons provide a better way to convey information (bottom).

Conclusions and Future Work

The main point of this paper is that for a large range of applications, cooperation among users while visiting a web site is a very important improvement over current practices. Museum applications belong to this class for a number of reasons:

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- They support a (potentially very) large body of knowledge
- The users have strong motivations to try to get the most out of their "virtual visit"
- Exchanging knowledge, comments and ideas with other people is an inherent part of an effective (and amusing) visit to a real museum. Why should it not be the same for virtual museums?

We have started analyzing the different components for making cooperation effective, recognizing that different situations require different organizations and different actions for cooperation. We have used the name "cooperation metaphors" to identify different cooperation solutions. Also, we have reviewed a number of tools, from the market or our own, in the light of the needs of implementing sophisticated cooperation metaphors.

In the future we will work in the following directions:

- Building new museum (and non-museum) collaborative applications, in order to gain further understanding of the key issues.
- Conducting theoretical and empirical research about the primitives making up effective cooperation metaphors, trying to obtain a more comprehensive list of elementary possibilities and a more complete set of ways of organizing them.
- Investigating the correlation between visual representations and cooperation metaphors.
- Completing the development of WebTalk-II, while, at the same time, keeping a close eye on industrial solutions offered by the market.

Among other application areas, (virtual) museums remain our favorite area of application for these general ideas.

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